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*MOSQUITOES FOUND ABOUT GAINESVILLE, FLA.

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MOSQUITOES AND DISEASE

Malaria has been known for a long time, but it is only recently that it has been shown to be caused by a sporozoan parasite, belonging to the family *Plasmodidae*, and that it is transmitted by, and only by, Anopheline mosquitoes.

The idea that mosquitoes might spread malaria had been suggested many times, but it was not until 1898 that Dr. Ronald Ross, of the London School of Tropical Medicine, worked out the life history of the parasite causing "bird malaria" and found the spores developing in the stomach of the mosquitoes. A little later, Grassi, following Ross' theory, demonstrated the transfer of human malaria by Anopheline mosquitoes. Since that time, it has been confirmed by such a large number of workers that there can no longer be any doubt.

*This is the second installment of Mr. Loftin's paper and concludes Part I. The first installment was printed in the previous number. Part II, "Traps for Mosquitoes," will appear in the next number. All the figures for Part I were printed in the previous number.

Theobald (1901) in his Monograph reports forty-two species of Anopheles from the world. There are eleven species found in the canal zone, at least five of which carry malaria (Darling, 1910). But we, in the United States, have only three that ordinarily carry malaria. These are *Anopheles punctipennis* Say., *Anopheles quadrimaculatus* Say., and *Anopheles crucians* Wied. (Howard, 1911), the last two being found in Florida.

While the etiology of malaria is well understood, few people realize the importance of it. They take it as a matter of providence that every one in the South should have it and that it does not amount to much. Indeed, it is very difficult to estimate the damage it does. But Herrick (1903) says that malaria is responsible for more sickness among the white population of the South than any other disease. Howard (1907) points out that from the meager data available, the death rate from malaria in the United States amounts to fifteen per hundred thousand, or twelve hundred per year, and that two-thirds of this is in the South. Although there are no records available for this state, Florida, with its semitropical climate, summer rains and large areas of flat lands, undoubtedly has its share. But the death rate alone does not begin to show the importance of the disease. Howard (1909) says:

"But with malaria perhaps as with no other disease, does the death rate fail to indicate the real loss from the economic point of view. A man may suffer from malaria throughout the greater part of his life, and his productive capacity may be reduced from fifty to seventy-five per cent, and yet ultimately he may die from some entirely different immediate cause. In fact, the predisposition to death from other causes brought about by malaria is so marked that if, in the collection of vital statistics, it were possible to ascribe the real influence upon mortality that malaria possesses, this disease would have a very high rank in mortality tables. Writing of tropical conditions, Sir Patrick Manson decided that malaria causes more deaths, and more predisposition to death by producing cachetic states predisposing to other affections, than all the other parasites affecting mankind together. However, it has been shown that the average life of the worker in malaria places is shorter and that infant mortality is higher than in healthy places."

Malaria is undoubtedly the most prevalent disease among the students. The records of the University Infirmary show that for the present scholastic year (up to May 5, 1913) there were a total of seventy-two cases treated in the infirmary, thirty-one of which were for malaria. This is in spite of the fact that there is, among the students, a strong aversion to going to the infirmary and that only the more serious cases were recorded. The records show that the time spent in the infirmary for treatment varies from one to ten days, with an average of three and one-tenth, or a total for the year of ninety-six. But, as pointed out

above, these records do not begin to show the loss of efficiency among the students, which is much higher than is shown by these bare records.

Yellow Fever

We have only to turn the pages of history to see how fatal an epidemic of yellow fever may be. In 1773, Philadelphia was nearly wiped from the map. In 1853 there was a severe epidemic throughout the South, New Orleans alone having a mortality of eight thousand. In 1878 another severe epidemic swept this region, and spread up the Mississippi Valley, causing twelve thousand deaths. In 1892 there were one hundred and ninety-two deaths at Pensacola, and more recently there was an outbreak, in 1905, in which nearly one thousand lives were lost. It was clearly demonstrated by Reed, Carroll, Lazear and Agromonte, a Board appointed by the Surgeon-General of the United States Army to investigate this disease, that yellow fever is carried by a mosquito, *Stegomyia calopus*. The work done in the recent epidemic, in 1905, shows that an epidemic can be stamped out by destroying these mosquitoes.

We have Stegomyia present in large enough numbers to cause trouble should an epidemic break out. I have killed as many as a half dozen in the laboratory in one afternoon, and for a while during the fall of 1911 they were very troublesome during the day at the Experiment Station. At present, there is no danger from them because we have no causal agent present to start an epidemic, but it may be introduced into Florida ports at any time, and this will be especially true with the increased trade incident to the opening of the Panama Canal.

Dengue fever is another mosquito-borne disease that is of increasing importance. Dr. J. H. Hodges, local agent of the State Board of Health, estimates that there were five thousand cases in this county alone last year. While this estimate is probably too high, it shows that this disease must be reckoned with in the future.

NATURAL ENEMIES OF MOSQUITOES

Some adult mosquitoes are destroyed by birds, bats, dragonflies, and other predacious insects, but their number is comparatively small.

A small mite determined by Dr. Nathan Banks as a Hydrachnid, close to the genue *Thyas*, has been found parasitic on the body of Anopheles. During October and November, it was found attached to from ten to fifteen per cent of the *Anopheles* caught,

but never in a single instance to *Culex*. As many as eight and ten have been counted attached to the thorax and abdomen of some individuals; but it is doubtful if any mosquitoes are killed by them.

The larvae are more easily preyed upon and we have some enemies that are very effective in holding them in check. There are a few water beetles, especially in the sinks, that feed upon the larvae. This community is a regular paradise for dragon-flies and there are from fifty to seventy-five species found. Anywhere around the grounds, on a quiet day, one can see scores of them. Their larvae feed upon mosquito larvae and being present in such large numbers devour many of them. Two well grown dragon-fly larvae have eaten thirty-five *Culex* larvae over night. Dragon-fly larvae have been found in the larger areas of water in all the marshes surrounding the University, but have not been found in the sink holes.

The most active enemies* we have are the little top minnows *(Gambusia affinis)* (Fig. 22, p. 22) and the "goggle-eye" or a warmouth bass *(Chaenobryttus gulosus)* (Fig. 23, p. 28). The usefulness of the top minnows has been mentioned by other writers (Howard 1902, Van Dine 1906). It is surprising how many mosquito larvae these little fellows will eat. A half dozen of them have eaten over a hundred Culex larvae in a couple of hours, and ten of them have eaten two hundred larvae (all that were fed them) for several days in succession. They are very active and one has only to stand quietly on the bank to see them as they patrol the water every few minutes. They have been found in the deeper portions of all the marshes, the sink holes, ditches, and wherever there is a permanent supply of water. Their small size enables them to go almost anywhere and to work their way in among the vegetation. Wherever they are found is a poor place to look for mosquitoes. They have been found in only one instance in the same pond with mosquitoes. This was in a circular depression covering four or five acres, lying about a mile northwest of the University. The depression is shallow and the slope from the bank toward the center is very gradual. It is overgrown with water weeds and in some places the edges are surrounded with sphagnum moss. *Anopheles* larvae were found abundant in some places among these weeds and moss. In some cases, the weeds and moss were so thick that the water could not be seen at all and it looked as though the larvae were actually

*Determined by Dr. H. S. Davis.

resting upon the moss. The minnows were all about the edges, but in some places the vegetation was too thick for even them. Wherever a little open water was found, there were the minnows but no mosquito larvae. They are very hardy and are entirely capable of freeing and keeping free from mosquitoes, any area of permanent water. They can be very readily introduced into ponds and aquaria that are not already stocked with fish of some kind. They are oviparous and breed all the year, so a few only would be necessary for a start.

In the sink holes we have also the "goggle-eye" which is predaceous upon mosquito larvae. Four of these ate two hundred full grown larvae and ten *Gambusia* in four hours. Another record shows that they ate one hundred and fifty *Culex* and thirty-five *Gambusia* within forty-eight hours, and still another that they ate three hundred *Culex* in one hour. The sinks are well stocked with them. I have several times caught fifteen or twenty in an hour with a hook and line. In about one hundred specimens caught, this was the only species found. They do not seem to prey upon Gambusia naturally, for both are found abundant in the same sink. It was very fascinating to watch one of these fish, six inches long, chase a tiny wriggler. They seem very hardy and can be kept in an aquarium without much trouble. These and *Gambusia* keep the sink holes entirely free. I have several times during the year, carefully examined the sinks without ever finding a single larva.

PREVENTIVES FOR MOSQUITOES

This subject is naturally divided into two parts. Preventives for (1) Adults and (2) Larvae. There are endless protective fluids that have been recommended for protection from the bite of the adult. These usually contain some essential oil such as oil of citronella, castor oil, pennyroyal oil, kerosene, oil of tar, etc., and many are undoubtedly repellant to mosquitoes. But all of them are more or less disagreeable to use and have to be frequently renewed to be effective, and, all in all, they are a poor makeshift.

Screens and canopies afford great protection, but as ordinarily used do not keep out all of the mosquitoes. Examination of rooms in Thomas Hall has shown as high as thirty mosquitoes present, ten of which were *Anopheles (crucians* and *quadrimaculatus).*

This is in spite of the fact that the dormitories have as good screens as money can buy, showing how hard it is to keep mosquitoes out if they are present.

Smudges of almost any material that give a dense smoke have been used and, if the smoke is thick enough, will keep adults away should anyone prefer to be suffocated rather than bitten to death.

Fumigants will quickly rid a house of the pests and are very useful in some instances. Sulphur dioxide, made by burning two pounds of sulphur per thousand cubic feet, has been the standard in the past and is absolutely reliable but it is objectionable to use on account of its injurious effect upon household goods. Pyrofume, a product obtained from the fractional distillation of pine wood, seems to be as effective as sulphur dioxide and less objectionable to use (Francis, 1906). Mimms' culicide, made by mixing equal parts by weight of melted carbolic acid crystals and camphor gum, used at the rate of four ounces per thousand cubic feet is entirely satisfactory but expensive. In experiments conducted by the writer, it killed all the *Culex quinquefasciatus* which were confined in the room in a battery jar covered with cloth. It is much easier to use and not so injurious as sulphur dioxide. Tobacco smoke will quickly kill mosquitoes confined in a tight receptacle. As tobacco is so universally distributed and cheap, it would be very convenient to use if it would form an effective fumigant. In experiments conducted by the writer, the great difficulty was in burning it so as to make a smoke. When alcohol or saltpeter was mixed in sufficient quantities to burn it, it would burn without making much smoke and was not effective when burned in a tight room at the rate of two ounces per thousand cubic feet. It is believed that if some device for burning tobacco so as to make a dense smoke can be perfected, it will form a cheap and efficient fumigant. Perhaps something like the "smoker" used for bees could be used successfully.

Tobacco decoction (containing about two and two-thirds per cent nicotine) was tried in a tight room containing about seven hundred cubic feet of space. Twenty-five cubic centimeters were evaporated over a gas burner and one hundred and four *Culex quinquefasciatus* exposed to the fumes for thirty minutes. All of them were stupefied, but when removed to fresh air, about seventy-five per cent revived. Another experiment was made in which ninty-five cubic centimeters were evaporated in the same room and about fifty *Culex quinquefasciatus* exposed to the fumes for one hour. In this experiment none of them were killed. Some trouble was found in evaporating this much of the decoction, as it forms a thick syrupy mass and vaporized slowly. It is thought that "Black Leaf 40" which contains nicotine sulphate can be

used to much better advantage, but none was available for experiment. As it contains about fifteen times as much nicotine per volume as the other decoction, probably no difficulty will be experienced in evaporating a sufficient quantity to kill the mosquitoes if it proves effective.

Oil of turpentine was tried as a fumigant, but it caught on fire so the experiment was discontinued. It burned with a dense smoke which completely filled the room, but did not kill the mosquitoes. Green camphor leaves dried in an oven and burned at the rate of two ounces per seven hundred feet were not effective.

It is important that the evaporating vessels for any fumigants be placed near the floor, otherwise the mosquitoes near the floor will not be harmed, as the fumes are lighter than air.

PREVENTIVES FOR LARVAE

Preventive and remedial work against the adults is desirable and often very effective, but it is only temporary and does not destroy the root of the trouble. It is better, in all cases where it is possible, to either kill the larvae or to destroy or render uninhabitable the breeding places. It is more satisfactory and usually cheaper in the long run to destroy the breeding places. The peculiar habits and structure of the larvae make it possible to kill them rather easily with substances called "larvacides." These substances float on the surface, forming a film which prevents the larvae from reaching the air with their breathing tubes. Various substances have been tried and many have given good results, but considering everything, petroleum products have proved the most satisfactory. It was suggested as early as 1812 that kerosene was effective in killing larvae, but the use of it did not become very general until about 1895. Since then it has been used extensively with good results. H. W. Weed rid the campus of the Mississippi Agricultural College of mosquitoes by oiling eleven water tanks. Professor Kellogg found that by pouring a little kerosene in some post holes that the mosquito plague was almost immediately alleviated at Leland Stanford University. Mr. W. C. Kerr did some extensive work on ponds and swamps on Staten Island, and Dr. J. B. Smith reports its successful use in two cases on Long Island. An oil suitable for this work should be light enough to spread rapidly and yet heavy enough not to evaporate too readily. A low grade oil known as fuel oil has been found best suited for this. Mr. H. J. Quayle (1906) used a mixture of a heavy, eighteen degree Baume, oil and a light, thirty-four degree

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It is not abundant, and is found predatory in both the larval and adult stage on the avocado red spider mite.

Prospaltella sp.—This species is a small hymenopterous parasite, frequently bred from the pupal and larval stages of the avocado white fly, *Trialeurodes floridensis* Q.

Cryptognatha (Delphastus) pallida, Lec.—This a small lady bird beetle, light brown in color and about the size of a pin head. It is one of the Scymnus group. The larvae are whitish in color. Both the larvae and adults are very beneficial, being predatory upon the avocado white fly in the larval and pupal stages.

Scolothrips sexmaculatus, Pergande.—This thrips, which is light in color, possesses six spots on the abdomen. It was not found by the writer to be abundant and feeds when present in both the larval and adult stages on all stages of the avocado red spider mite, *Tetranychus yothersi,* McG.

Aspidiotiphagus citrinus, Craw.—A hymenopterous parasite found to be destroying considerable numbers of the dictyospermum scale, *Chrysomphalus dictyospermi,* M.

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Baume, oil in some pool and creek beds that could not be readily drained, with good success. He found this to be efficient for from one to four weeks, depending upon the nature of the pond and the exposure to the wind. To be on the safe side, the pond should usually be oiled every two weeks. He used a barrel spray pump in the accessible places and a knapsack pump in the others to good advantage, but it may be simply poured on from a sprinkler or applied from a bucket with a mop. In inaccessible swamps, it is sometimes applied by standing a barrel on end and boring a small hole near the bottom so there will be a constant drip.

In the Panama Canal work there was considerable difficulty in getting the oil to completely cover the surface when the vegetation was thick. There they found a solution made from one hundred and fifty pounds of sulphuric acid, one hundred and fifty pounds of powdered resin, and thirty pounds of caustic potash boiled together made a good larvaecide (Gorgas 1909), which, in some cases, was more effective than fuel oil.

A pool on the campus between Buckman and Science Halls, and the septic tank back of Thomas Hall, have been treated with "Zenoleum" disinfectant twice. This forms a milky mixture with the water and kills the larvae in a short time. Both pupae and larvae were found alive four hours after application, but all were dead next morning. No record was obtained of how much was applied, but enough to make the water appear decidedly milky. It was found to prevent egg laying for about twelve days, and should be applied about every two weeks.

Ordinary kerosene is commonly used when only small areas are to be oiled. It is more expensive than crude oil and not any more effective.

Any system of oiling has to be done every few weeks during the year, which in the long run, proves expensive. It is cheaper after all to drain the breeding places, as they then require very little attention.

Drainage

Drainage has become more popular in recent years and large areas, that it would have been thought foolish to attempt to drain a few years ago, have been successfully drained. Perhaps the most extensive work has been done in the New Jersey salt marshes by Dr. J. B. Smith (Smith 1901-1911). Salt marsh mosquitoes are long distance flyers (forty miles in some cases) and large areas had to be drained to control them. Something of the magnitude of the work in general is gathered from the following figures. Up to 1911, about thirty thousand acres had been drained and nearly four million feet of ditches dug at a cost of about $75,000 (Smith 1911). Wherever this work has been done, the mosquitoes are practically eliminated and it has proved successful in every way. This work has been accompanied by considerable oiling, as is usually the case, to give immediate relief, and in some places where it was not practicable to drain.

Numerous other cases of the eradication of these pests and the diseases they carry, by these remedial measures are on record. Prior to 1905, a house to house inspection showed that twenty per cent of the population in some parts of Staten Island were suffering from malaria. Anti-malaria work was undertaken, and in 1909 there were only five cases of malaria reported (Howard 1910). Dr. E. P. Felt (1905) states that Lawrence, Long Island, has been freed from the salt marsh mosquitoes. H. J. Quayle (1906) reports some very satisfactory work against the salt marsh mosquito near San Francisco. The Lawrence, L. I., Board of Health (1903) has done good work which has rid their town. Havana, Cuba, has been cleared of yellow fever and made habitable by anti-mosquito work done under direction of the United States Medical Army Corps. The epidemic of yellow fever in New Orleans, in 1905, was stamped out by clearing the city of mosquitoes. Some of the most successful, as well as the most difficult anti-malarial work, has been done in the Panama Canal Zone. Under the French administration this was a veritable death trap. The tales told of the deaths are almost unbe-

lievable; in fact it was difficult to keep enough men there to keep records. When the Americans took charge, the first thing done was to organize a Department of Sanitation to clear the zone of mosquitoes and fever. This has been so successful that it is now considered a health resort. Their hospital reports show (Gorgas 1913) that their monthly average of cases sent to the hospital for malaria was only ninety-two hundredths of one per cent of the entire force, while similar records at the University show ten per cent.

These facts leave us no room for doubt as to the efficiency of these methods. If Staten Island and Long Island, surrounded by water; if New Jersey with her thousands of acres of marsh and mosquitoes flying forty miles, and Panama with her tropical rains and with excavations made by buildings, can be freed from mosquitoes and malaria, why cannot most towns in Florida? They can.

STRATEGUS WANTED—Am making a special study of this genus, of the Scarabeidae, and should be very glad to receive Florida specimens, especially of the rarer species. Will exchange or pay cash. Address W. Knaus, McPherson, Kansas.
